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ABSTRACT

A study investigated the effects of chartoons--cartoon-like informational graphics--and three-dimensional graphs on the attractiveness of graphs and on the information gain from graphs. Subjects, 86 students from a mass communication course at the University of Texas, were randomly assigned to two experimental groups, each of which was shown a set of six graphs. The sets were counterbalanced so that if one group saw a particular graph in the chartoon version, the other group saw it in the plain version. Likewise, if one group saw a particular graph in the three-dimensional version, the other group saw it in the plain version. Subjects rated each graph on five semantic differential-type scales indicating interest and appeal of the graph, and answered 18 multiple choice questions based on information presented in the graphs. Results showed that both chartoons and three-dimensional graphs were found to be more appealing than plain graphs. This finding held up more strongly for chartoons than for three-dimensional graphs, with only two of the three-dimensional graphs rated as more appealing than their counterparts. Findings also indicated that chartoons and three-dimensional graphs led to an equal amount of information retention as plain graphs. Finally, findings did not indicate a positive correlation between readership of "USA Today" and information gain. (Five tables, 12 figures, and 13 notes are attached.) (ARH)

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Effects of Chartoons and Three-Dimensional Graphs on Interest and Information Gain

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A paper presented to the Visual Communication Division of the Association for Education in Journalism and Mass Communication at the annual convention in Portland, Oregon, July, 1988.

Effects of Chartoons and Three-Dimensional Graphs on Interest and Information Gain

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An experiment was conducted to investigate the effects of chartoons -- cartoon-like informational graphics -- and three-dimensional graphs on the attractiveness of graphs and information gain from graphs. Both chartoons and three-dimensional graphs were found to be more appealing than plain graphs. Much that has been written about effective graphs suggests that both forms should lead to less information gain than plain graphs, but this was not found to be the case.

Effects of Chartoons and Three-Dimensional Graphs on Interest and Information Gain

Introduction

Informational or quantitative graphics are being used more and more by newspapers, with USA Today being the conspicuous leader in the movement. The chartoon, a hybrid of a chart and a cartoon, is a new form that has become especially popular [1] The chartoon typically combines pictorial elements, such as people, animals or symbols, with a graph presenting data. A more simple kind of graphical elaboration is just to add depth to a two-dimensional graph, turning it into a three-dimensional object

Both types of graphical enhancement are probably used in an effort to add interest and attract attention to the graph. Editors at USA Today speak of their efforts to make their graphics "vibrant."[2] Cricket Graph, a chart-creation program for the Macintosh computer used at numerous newspapers, has a program feature that adds depth to any graph, and the manual recommends the technique for adding "pizzazz" to a graph for presentation.

But some writers have cautioned that graphs should be kept as simple as possible for effective communication, and that overly-complex graphs might actually hinder communication. Tufte recommends that effective graphics have a high data-ink ratio, or ratio of ink presenting data information to total ink used to print the graphic. He cautions against the use of chartjunk -- over-busy grid lines, cross-hatching and other graphic elements

routinely added to every graph. He also warns against the duck, a graph in which graphical style or ornamentation overwhelms the quantitative information.[3]

Tankard has argued that chartooning can create graphs that are misleading, unclear or inaccurate.[4]

It appears that there is some disagreement over the effectiveness of chartoons and three-dimensional graphs. The people who create them obviously think they are effective, probably because they are trying to attract attention to graphs they believe would otherwise be dull. But critics suggest chartoons may be distracting and therefore might hinder communication. The object of this study was to conduct an experiment comparing the effects on the viewer of chartoons with plain graphs, and also of three-dimensional graphs with plain graphs. The experiment was designed to determine the effects of chartoons and three-dimensional graphs on viewer interest in graphs and viewer information gain from graphs.

Related Studies

Several authors have warned about the difficulty of creating clear graphs.

Ehrenberg has written about tables rather than graphs, but the conclusions might also be applicable to graphs. He contends that most statistical tables are badly presented and that understanding them requires a great deal of effort. In an effective table, he argues, patterns and exceptions should be obvious at a glance.[5]

Hartley cautions against the use of pictograms or symbols to convey numbers because many, if not most, symbols are ambiguous for at least some people. He also warns against the use of three-dimensional objects in graphs, because they require the viewer to compare areas or volumes rather than lengths.[6]

Roller studied the comprehension of graphs by a sample of seventh graders. She tested their reading, interpretation and summarization skills in dealing with graphs. She found evidence that the more things compared and displayed on a graph, the more difficult the graph becomes. Her subjects saw those graphs as difficult where the illustrator had tried to put "too much" into a compact space. Many of her subjects exhibited behavior similar to that of first graders learning to read, suggesting that reading graphs is a skill that must be learned.[7]

Tankard's study identified 10 pitfalls to be avoided in the creation of quantitative graphics. One of the types he cautioned against is the unnecessarily three-dimensionsal graph.[8]

Theory

It seems reasonable to predict that chartoons and three-dimensional graphs will lead to increased liking and interest, as the creators of these forms in newspapers and other media believe. When it comes to the effects of chartoons and three-dimensional graphs on information gain, however, it is possible to make two contrasting predictions. On the one hand, greater attention might lead to greater learning. The assumption might be that people are not going to acquire any information from the graph unless they

attend to it, and that they will not attend to it for very long unless it is "spiced up" with chartooning or added depth. This reasoning would lead one to predict that chartoons and three-dimensional graphs would lead to greater information gain than plain graphs.

On the other hand, however, a number of theories would lead us to expect that chartoons and three-dimensional graphs would lead to decreased information gain. Tufte's concept of data-ink ratio provides one approach. Both the chartoon and the three-dimensional graph contain more ink than the plain graph, and it could be argued that the added and unnecessary ink will distract the viewer from the ink that is carrying data information. Also, the additional non-data ink could mean the viewer has to work harder to determine what is meaningful and what is not. Finally, the data-ink ratio can be taken as a measure of the complexity of the graph, and Roller and others have suggested that more complex graphs are more difficult to understand.

Another argument for chartoons and three-dimensional graphs leading to less information gain comes from a basic principle of Gestalt psychology, the figure-ground relationship. Psychologists indicate that the most basic perceptual experience is of a figure and a ground. The figure appears at a definite location, solid, and in front of the ground. The ground appears amorphous, indefinite, and continuous behind the figure.[9] The distinction between figure and ground is not always inherent in the stimulus material, however. This is shown by the Peter-Paul goblet, which can be viewed one moment as the faces of two twins looking at one

another or the next moment as a goblet. A common phenomenon is that the viewer can see only one Gestalt -- the twins or the goblet -- at a time. A similar phenomenon might occur with chartoons and three-dimensional graphs, and particularly with those chartoons in which the same line illustrates a change in the data but is also part of a drawing of a person or object. Perhaps the viewer who sees the person or object will tend not to see the lines portraying data.

A third argument for chartoons leading to less recall comes from schema theory. People process information in terms of schemas, or scripts. Simkin and Hastie have applied schema theory to perception of graphs and have argued that people have distinct schemas for bar charts and pie charts.[10] Chartoons, however, bring other schemas to bear by providing cartoonish illustrations related to the content of the graph. These conflicting schemas could be confusing for the viewer, and lead to less information gain.

Finally, it is possible to make a prediction about the kind of people who are likely to be good at reading graphs. If it is necessary for viewers to learn to read graphs, as suggested by Roller, it seems reasonable to predict that visually (or graphically) literate people would be able to understand chartoons better than visually illiterate people. In this study, readership of USA Today, which frequently publishes both chartoons and three-dimensional graphs, will be used as a measure of graphical literacy.

Hypotheses

The rationale presented above led to the following five hypotheses:

H_1: Chartoons will be perceived as more appealing than plain graphs.

H_2: Three-dimensional graphs will be perceived as more appealing than plain graphs.

H_3: Chartoons will lead to less retention of information than plain graphs.

H_4: Three-dimensional graphs will lead to less retention of information than plain graphs.

H_5: The more frequent the readership of USA Today, the greater the retention of information from a graph.

Method

An experiment was devised to test the hypotheses by exposing two groups of subjects to graphs of different types and measuring their interest and information recall.

Six basic graphs were prepared displaying statistical information. All were based on actual newspaper graphs, although they were typically simplified somewhat for the experiment.[11] Graphs were drawn on the Macintosh computer using MacDraw, Cricket Graph and MacBillboard. Three graphs -- a bar chart, a pie chart and a line chart -- were prepared in both plain and chartoon versions, and three other graphs -- again, a bar chart, a pie chart and a line chart -- were prepared in both plain and three-dimensional versions. Each chartoon was identical to the

corresponding plain graph except that pictorial elements were added. In the bar chart dealing with beer sales, the bars were replaced with mugs of beer. In the pie chart dealing with music sales, a clef was added so that the pie chart was part of a musical note. In the line chart representing a bull market, a bull was drawn with the line in the line chart becoming the back of the animal. Each three-dimensional graph was identical to the corresponding plain chart except that lines were added to add depth or convert the graph into a three-dimensional object. The graphs are reproduced in Figures 1-12. Slides for projection were prepared of each graph.

Subjects for the experiment were 86 students from a class in "Theories of Mass Communication." They were randomly assigned to two experimental groups. Because of uncertainty about the number of students that would be there on the first day of the experiment, the randomization could not be done in a way that would create two groups of equal size. Consequently, there were 49 subjects in group 1 and 37 in group 2. The first group participated in the experiment on the first class day and the second group participated in it on the next class day, two days later.

Each group was shown a set of six graphs. The sets were counterbalanced so that each group would see some plain graphs, some chartoons and some three-dimensional graphs. If one group saw a particular graph in the chartoon version, the other group saw it in the plain version. Likewise, if one group saw a particular graph in the three-dimensional version, the other group

saw it in the plain version. The assignment of particular versions of graphs to groups is shown in Table 1.

Subjects were shown each graph for one minute. During that time, they were asked to rate each graph on five semantic differential-type scales and then to look at the graph "as you would normally look at a graph in a newspaper." They were also told they would be asked questions later to see what information they had gained from the graphs. The semantic differential-type scales were selected to measure interest or appeal. The scales were interesting-uninteresting, dull-exciting, pleasant-unpleasant, weak-strong and appealing-unappealing.

After the subjects finished looking at the six graphs, they were given a set of 18 multiple choice questions, or three for each graph, based on information presented in the graphs. These questions usually included one general question on the overall point of the graph and two questions asking for recall of specific numbers in the graph. The subjects were also asked whether or not they were regular readers of USA Today, and to indicate how often they read USA Today: daily, several times a week, once a week, once a month or never.

Results

An index of appeal for each graph was constructed by scoring the semantic differential-type rating scales from 1 for the least favorable end to 7 for the most favorable end and adding the scores for the five scales. This summing produced an index that could range in value from 5 to 35.

An information gain score for each graph was constructed by counting the number of correct answers to the three questions for that graph. This summing produced an information gain score that could range in value from 0 to 3.

Hypotheses 1-4 were tested by comparing means on the appeal scores and information gain scores for the two experimental groups by means of *t*-tests.

The test of hypothesis 1, that chartoons will be perceived as more appealing than plain graphs, is reported in Table 2. The hypothesis is supported for all three graphs, with *t*-tests showing significant differences between means.

The test of hypothesis 2, that three-dimensional graphs will be perceived as more appealing than plain graphs, is reported in Table 3. The hypothesis is supported for two of the three graphs. It is not supported for the pie chart dealing with causes of death, where no significant difference was found between the mean ratings.

The test of hypothesis 3, that chartoons will lead to less retention of information than plain graphs, is reported in Table 4. The hypothesis is not supported for any of the three graphs.

The test of hypothesis 4, that three-dimensional graphs will lead to less retention of information than plain graphs, is reported in Table 5. The hypothesis is not supported for any of the three graphs.

Hypothesis 5, which suggested that the more frequent the readership of USA Today, the greater the retention of information from a graph, was tested by a correlation coefficient. The

question about how often they read USA Today was used as a measure of readership by assigning scores of 1 to 5, with 5 for a response of "daily" and 1 for a response of "never." A total information gain score was constructed by summing each subject's total number of correct answers on all 18 questions. Information gain scores ranged from 5 to 15 correct out of the 18 questions. The correlation between the measure of USA Today readership and this measure of information gain was .13, which was not significant. One factor contributing to the low correlation may have been the fact that readership of USA Today was generally low. Only three of the 86 students reported they read the newspaper regularly. In response to the question about how often they read USA Today, 44% checked "never," 42% checked "once a month," 5% checked "once a week," 2% checked "several times a week," and 4% checked "daily" (the remaining 3% didn't answer)

Summary and Conclusions

This study found general support for hypotheses that chartoons and three-dimensional graphs are perceived as more appealing than plain graphs. These findings back up the arguments of graphics editors and computer graphics packages that these kinds of graphs have "vibrancy" and "pizzazz." The hypothesis for chartoons held up more strongly than the one for three-dimensional graphs, with only two of the three three-dimensional graphs rated as more appealing than their plain counterparts.

The study did not find support for hypotheses that chartoons and three-dimensional graphs will lead to less retention of information than plain graphs. The mean retention scores were typically fairly close for the two conditions being compared, and they were never significantly different by a t-test.

The fifth hypothesis, which suggested a positive correlation between readership of USA Today and information gain, was not supported. As noted, this may be because readership of USA Today in the student sample was generally low. There might indeed be a positive correlation between visual literacy and information gain from graphs if a better measure of visual literacy were used.

The findings of no difference in information gain between chartoon and plain graphs or between three-dimensional and plain graphs are difficult to interpret. It may be the case that chartoons and three-dimensional graphs do not have an adverse effect on information retention from graphs. But there are also a number of other possibilities.

1. Perhaps a difference in information retention did not show up because the sample was too small, and it would show up with a larger sample. This does not seem likely, however. The means were so close in most of the comparisons that they probably would not be significantly different unless the sample were much larger.

2. Perhaps the chartoons and three-dimensional graphs used in this experiment were not different enough from the plain graphs to have an effect. In general, the chartoons used in the

experiment were not as cluttered with cartoon-like detail as graphs in USA Today. Perhaps if the experiment were done with a heavier degree of chartooning in the chartoon versions, the distraction hypothesis would be supported.

3. One factor that might be important is that the experiment was conducted in an academic classroom, and at the end of a regular class meeting. Perhaps subjects were stimulated by this environment to be more motivated to gather information from the graphs than they would while reading a newspaper in a more typical setting. This factor did not stimulate everyone to perform equally, however, since the number of information questions answered correctly out of 18 ranged from 5 to 15

4. Another possibility is that subjects gained little information from any of the graphs, regardless of the form This does not appear to be the case, however. Overall, subjects got 9.57 of the 18 questions correct, or about 50%. By chance they should have gotten 20% correct.

5. Perhaps the information gain test wasn't sensitive enough to pick up the differences in information retained. It is difficult to think of a way to make this measure more sensitive, however. For each graph, the information gain measure consisted of one question dealing with the overall point of the graph and two questions dealing with specific numbers on the graph. There don't seem to be many other types of questions dealing with the graphs between the very general and the very specific.

One likely explanation of the results is that readers get the main point of a graph, whether plain chart, three-dimensional

graph or chartoon, very quickly, and then stop attending to the graph. If this is the case, research probably would not find differences in comprehension scores between the various types of graphs. Most people in any of the three conditions would tend to get a general question about the main point of the graph correct and questions about the details wrong. Examination of responses to the information questions one by one tends to support this explanation.

Perhaps a good graph tells a story. The story is the main point, and, if the graph is an effective one, most readers get the point quickly. Then they essentially ignore the supporting detail. Graber's research on how people process news stories shows that news stories are processed this way.[12] Maybe the same thing is true of graphs.

How can the results of this research be reconciled with the theoretical predictions earlier in the paper that chartoons and three-dimensional graphs would lead to lessened information gain? It is difficult to give a definitive answer, but it is possible to speculate. Tufte's concept of data-ink ratio is logical in terms of clean graph design and the aesthetics of graphs, but perhaps the amount of non-data ink in a graph doesn't make much real difference to the average newspaper reader. Likewise, the basic schemas that Simkin and Hastie have found for processing bar graphs and pie charts might not be incompatible with chartoons or three-dimensional graphs. Whether the bars in a bar chart are flat rectangles or pictures of celery stalks may not matter much as long as people can tell that they are supposed to be bars.

Finally, the switch back and forth between the pictorial elements of a chartoon and the lines representing changes in data may not be as difficult as the Gestalt switch in the Peter-Paul goblet, which, after all, is probably constructed to be somewhat difficult

Several additional kinds of research are suggested by the present study. One need is for further research on how people process graphs. Do they use the approach of thinking of a graph as telling a story, and, once they get the story, no longer attend to the graph? Several works on applying schema theory to visual material could be useful in this regard, including that of Simkin and Hastie and that of Winn.[13]

Another important step would be to repeat this kind of experiment with an even stronger degree of chartooning. The degree of chartooning used in this experiment was what might be characterized as mild to moderate -- it did not reach the amount of complexity used in the typical USA Today graph.

On the basis of this research, it is difficult to advise newspaper or magazine graphic artists not to use mild to moderate chartoons or three-dimensional graphs. These techniques do appear to enhance the attractiveness of a graph, as editors and artists have suggested, and there is little or no evidence here that they lead to less information gain. These conclusions might not hold up with stronger degrees of chartooning, however; undoubtedly it is possible to put enough confusing detail in a graph that it will eventually be incomprehensible.

Table 1

Versions of Each Graph Seen by Each Experimental Group

	Group 1	Group 2
Top-Selling Beers	plain	chartoon
Music Sales	chartoon	plain
Bull Market	plain	chartoon
Births per Day	three-dimensional	plain
Causes of Death	plain	three-dimensional
Computer Sales	three-dimensional	plain

Table 2

Comparison of Appeal Scores for Plain Graphs and Chartoons

		Version	Mean	t	p
1.	Top-Selling Beers	plain	21.35	4.25	<.001
		chartoon	26.73		
2.	Music Sales	plain	13.92	8.30	<.001
		chartoon	25.31		
3.	Bull Market	plain	14.35	7.69	<.001
		chartoon	24.81		

Table 3

Comparison of Appeal Scores for Plain Graphs and Three-Dimensional Graphs

	Version	Mean	t	p
1. Births per Day	plain	18.41	3.69	< 001
	three-dimensional	23.57		
2. Causes of Death	plain	21.04	1.86	n.s.
	three-dimensional	18.62		
3. Computer Sales	plain	17.84	2.34	<.02
	three-dimensional	21.12		

Table 4

Comparison of Information Gain Scores for Plain Graphs and Chartoons

		Version	Mean	t	p .
1.	Top-Selling Beers	plain	1.71	.80	n.s.
		chartoon	1.86		
2.	Music Sales	plain	1.86	1.31	n.s.
		chartoon	1.63		
3.	Bull Market	plain	1.43	.68	n.s.
		chartoon	1.30		

Table 5

Comparison of Information Gain Scores for Plain Graphs and Three-Dimensional Graphs

	Version	Mean	t	p
1. Births per Day	plain	1.32	.47	n.s.
	three-dimensional	1.24		
2. Causes of Death	plain	2.18	.52	n.s.
	three-dimensional	2.08		
3. Computer Sales	plain	1.30	.29	n.s.
	three-dimensional	1.24		

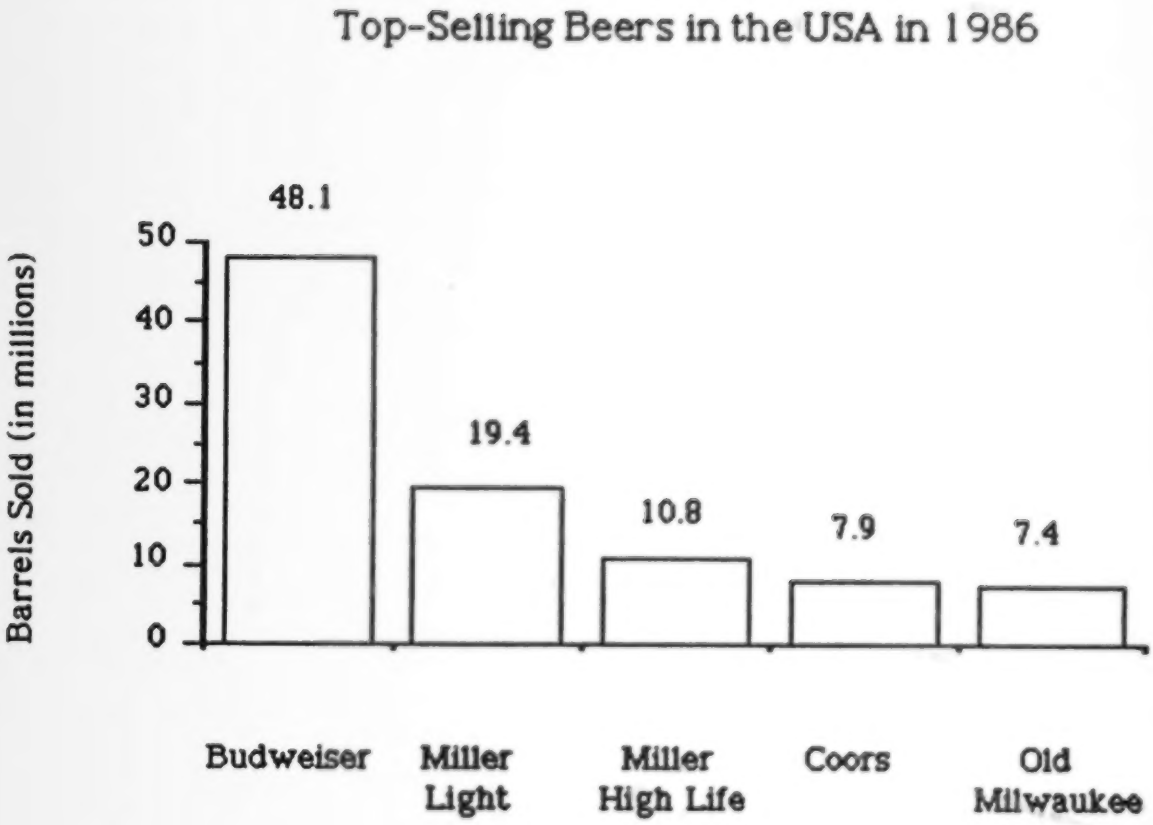

Figure 1. Top-Selling Beers, Plain Graph Version

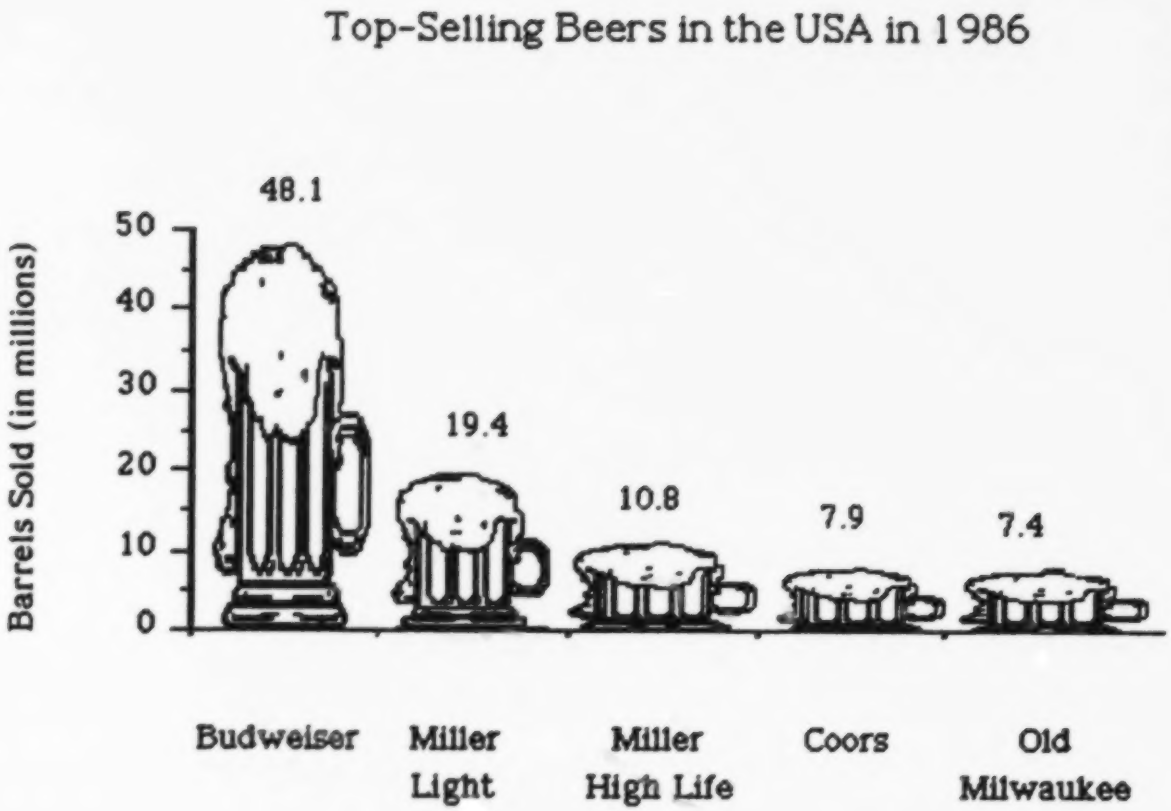

Figure 2. Top-Selling Beers, Chartoon Version

Rock Music Reigns in Sales in 1985

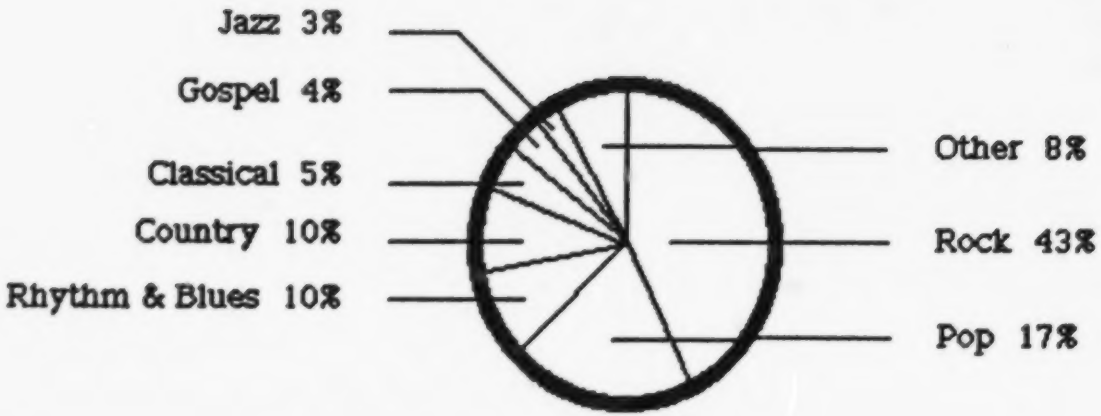

Figure 3. Music Sales, Plain Graph Version

Figure 4. Music Sales, Chartoon Version

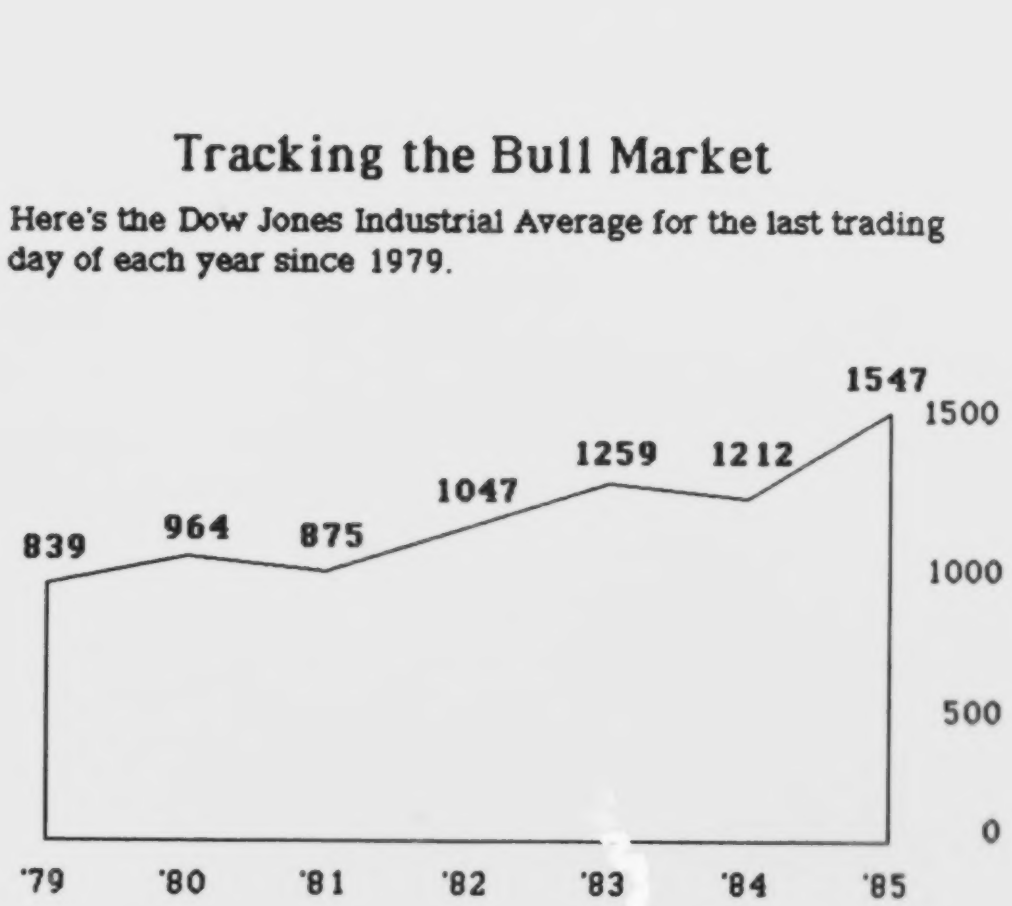

Figure 5. Bull Market, Plain Graph Version

Tracking the Bull Market

Here's the Dow Jones Industrial Average for the last trading day of each year since 1979.

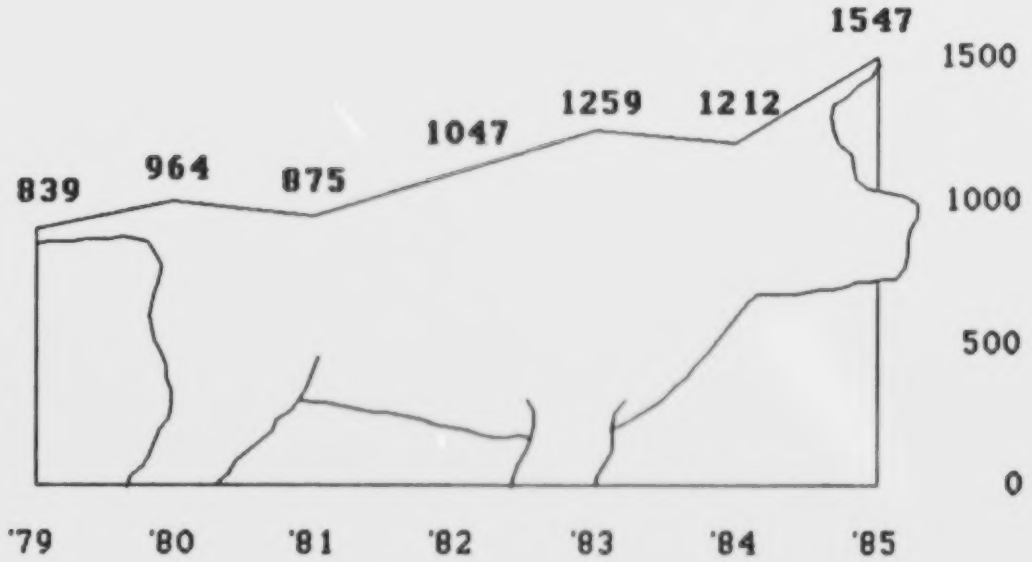

Figure 6. Bull Market, Chartoon Version

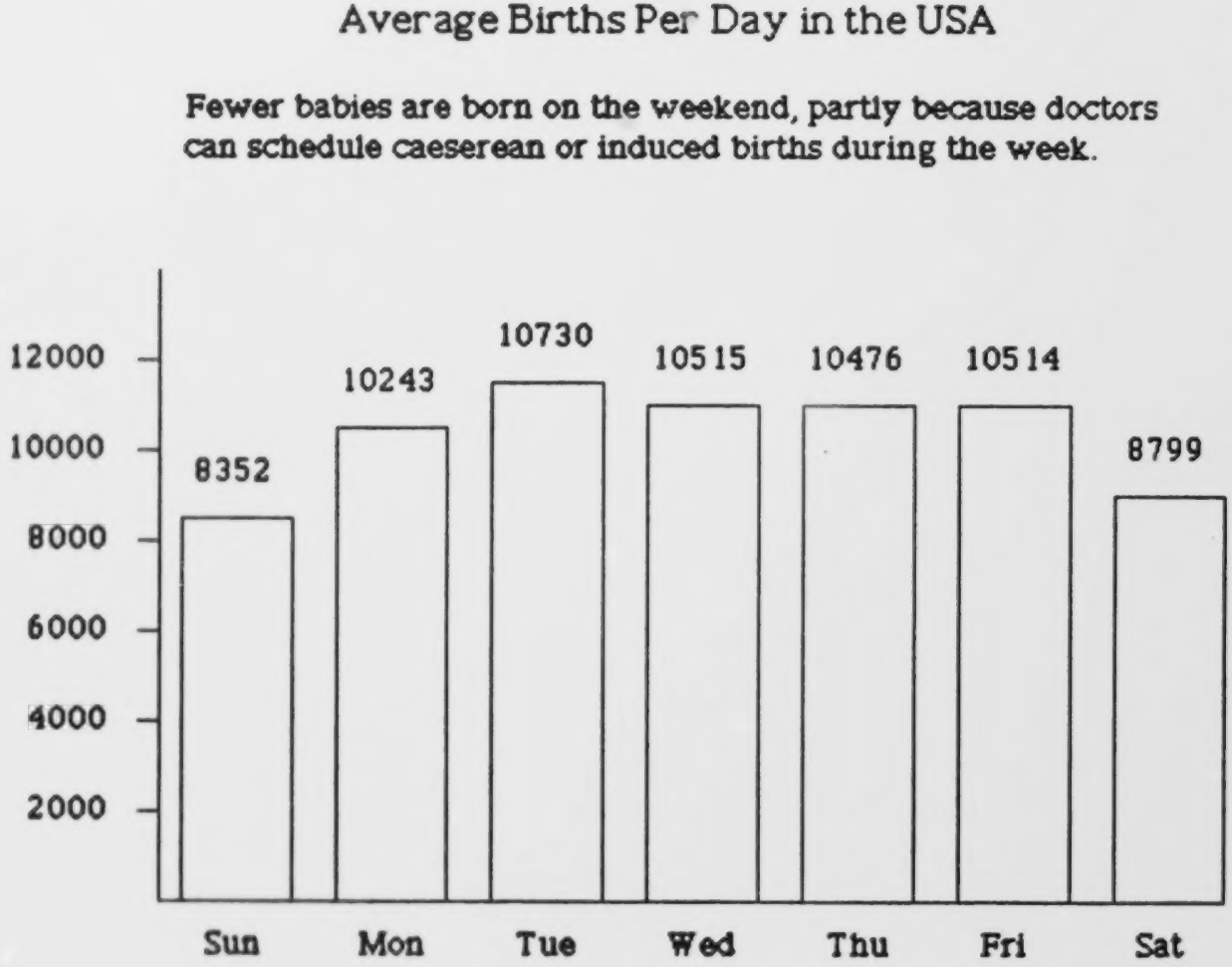

Figure 7. Births per Day, Plain Graph Version

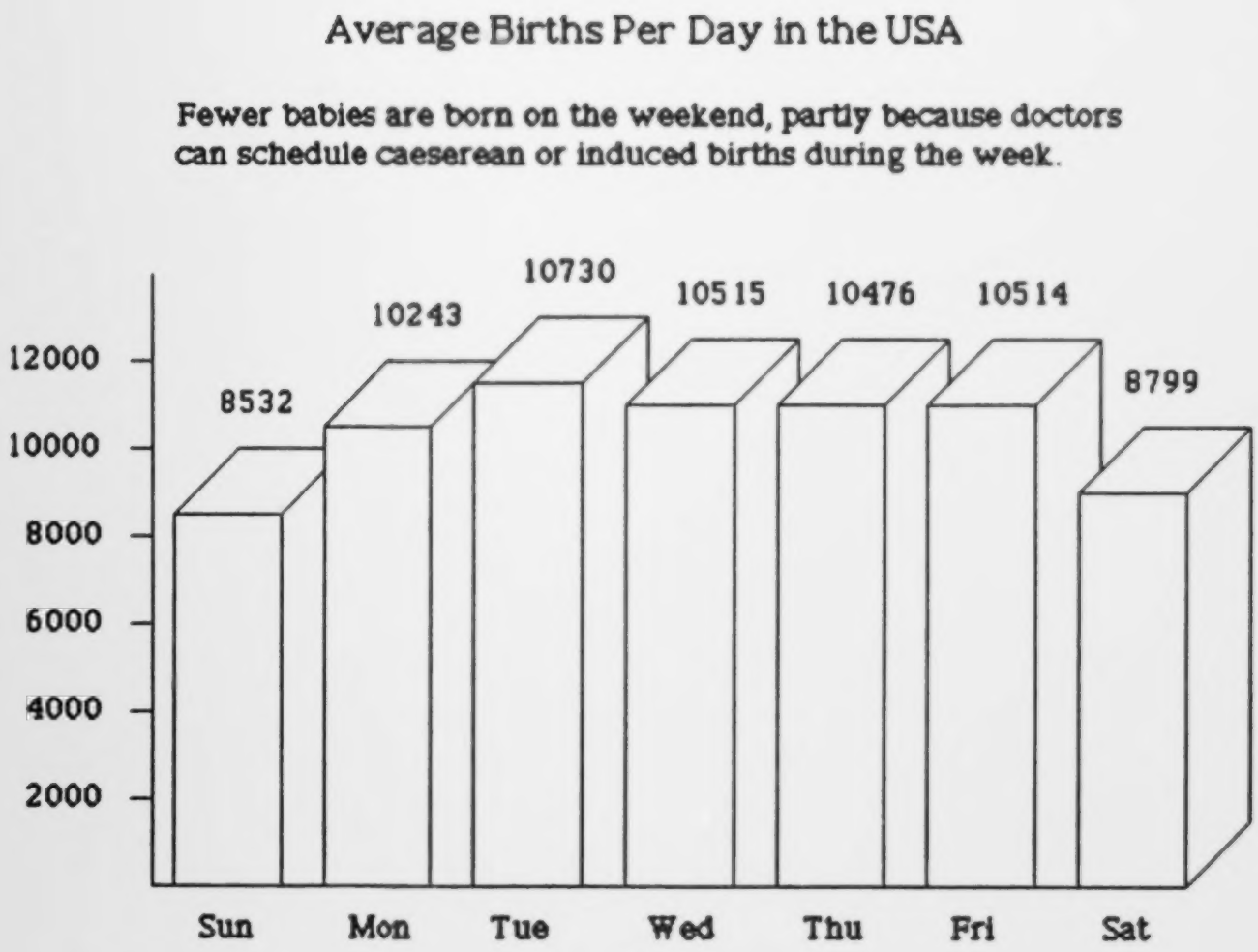

Figure 8. Births per Day, Three-Dimensional Version

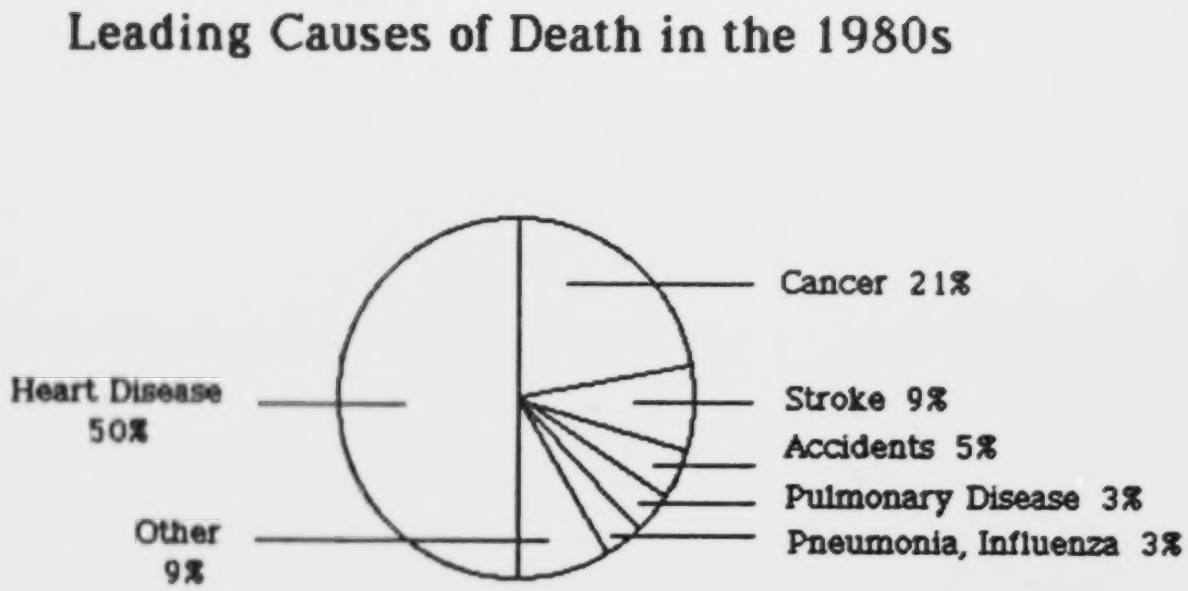

Figure 9. Causes of Death, Plain Graph Version

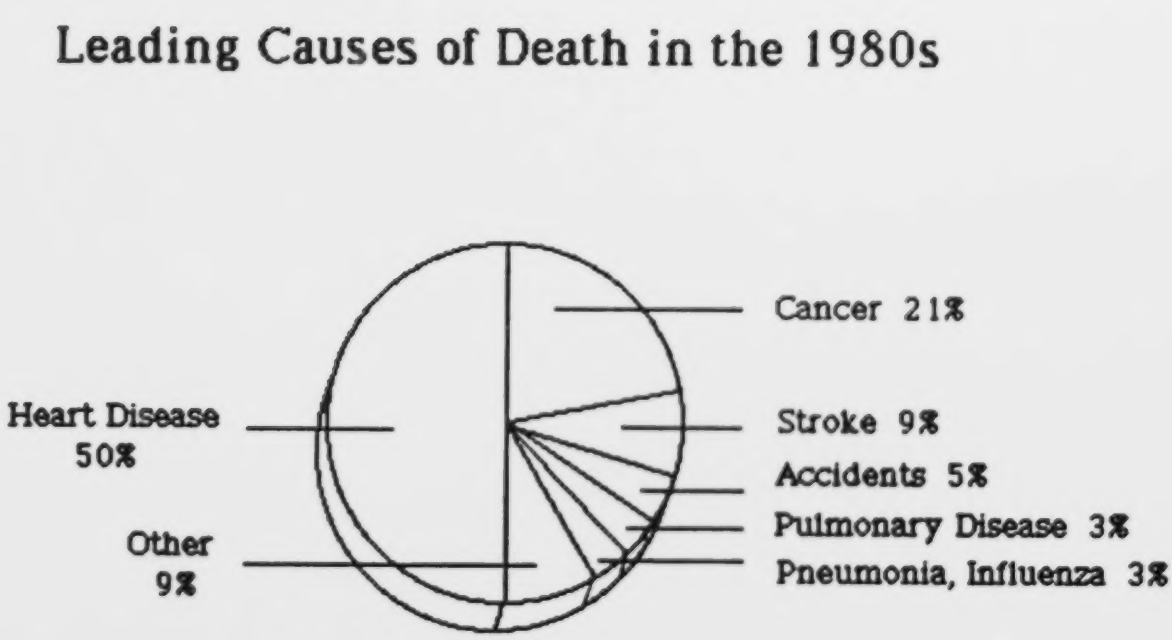

Figure 10. Causes of Death, Three-Dimensional Version

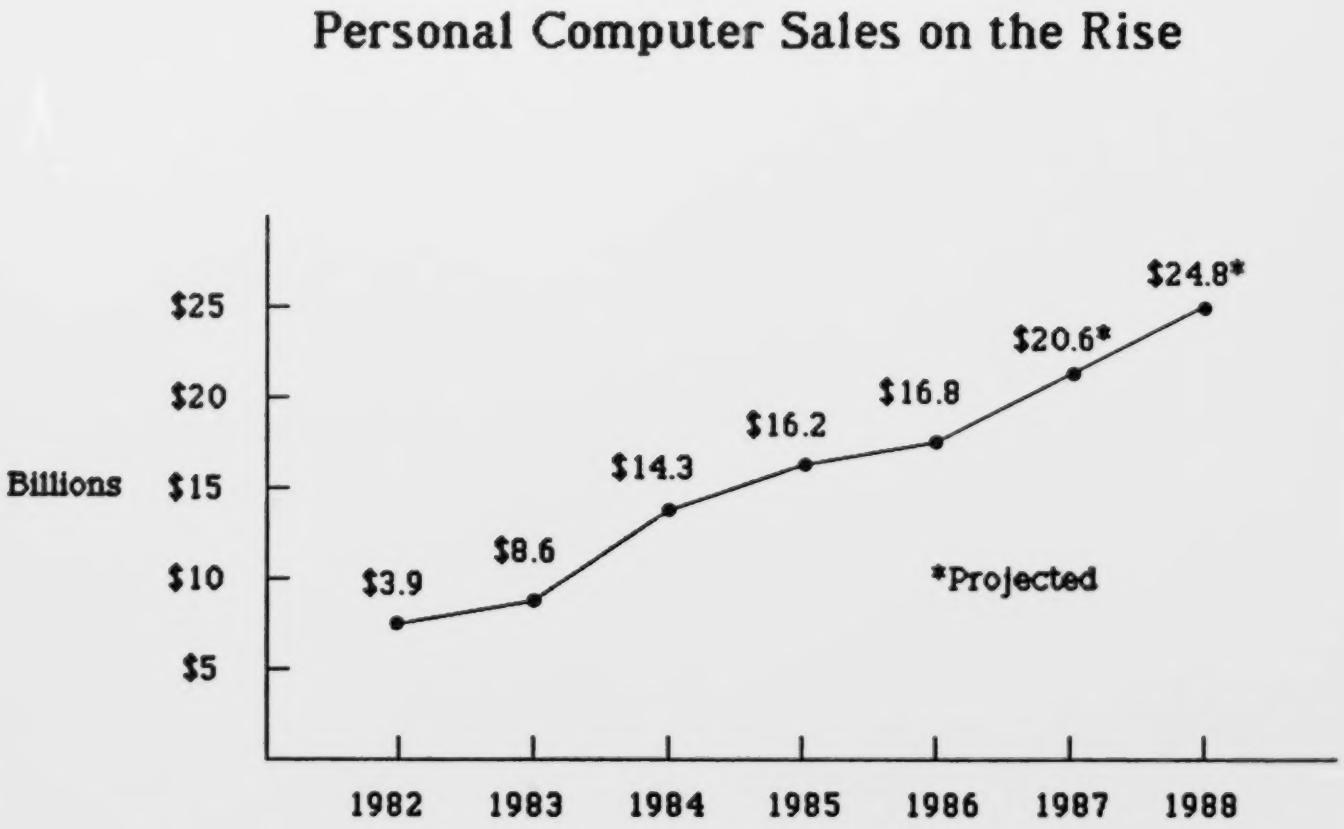

Figure 11. Computer Sales, Plain Graph Version

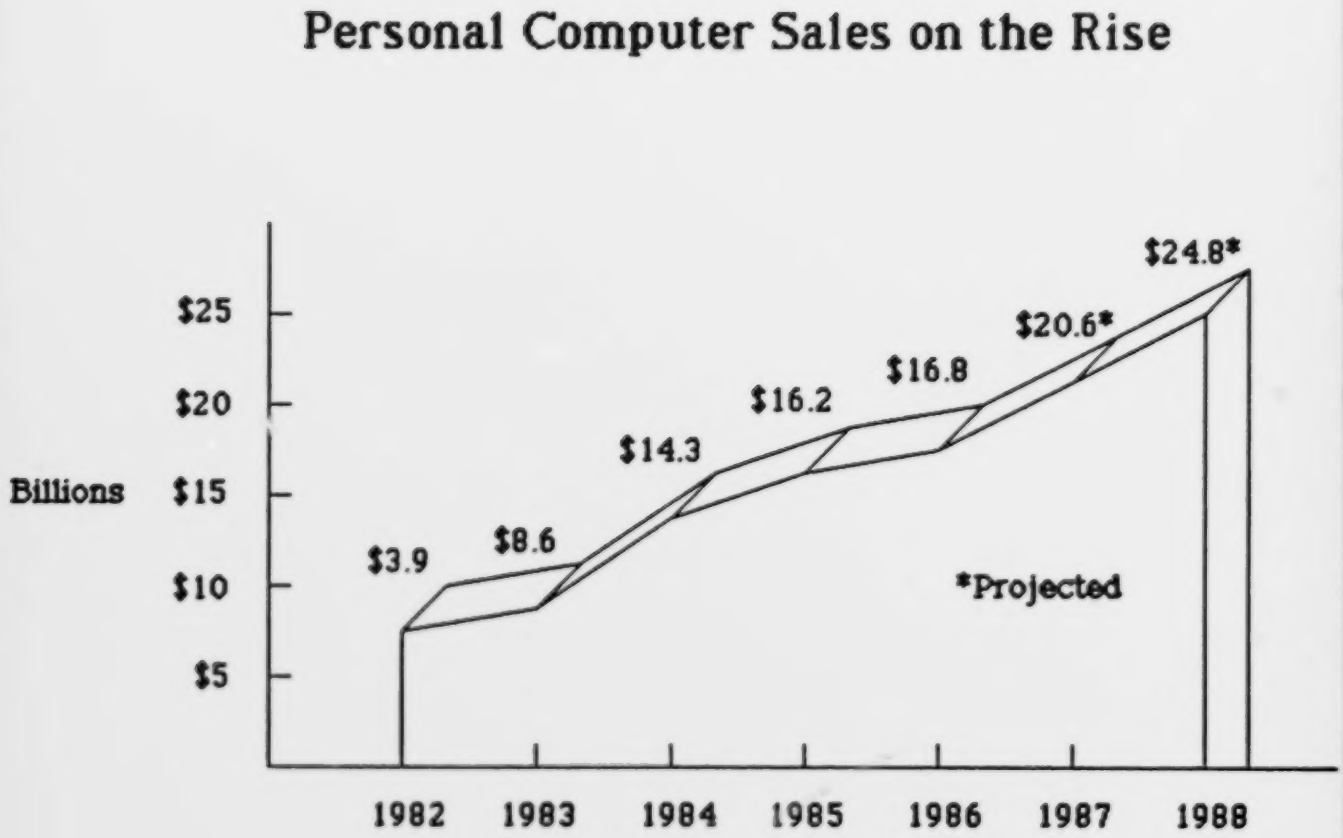

Figure 12. Computer Sales, Three-Dimensional Version

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[1]James W. Tankard, Jr., "Quantitative Graphics in Newspapers," Journalism Quarterly, 64:406-415 (Summer-Autumn 1987).

[2]Katharine Seelye, "Al Neuharth's Technicolor Baby," Columbia Journalism Review 21, No. 6:31 (March/April 1983).

[3]Edward R. Tufte, The Visual Display of Quantitative Data (Cheshire, Conn.: Graphics Press, 1983), pp. 93, 107, 116.

[4]Tankard, op. cit.

[5]A.S.C. Ehrenberg, "Rudiments of Numeracy," Journal of the Royal Statistical Society, Series A, 140, Part 3:277-297 (1977).

[6]James Hartley, "Eighty Ways of Improving Instructional Text," IEEE Transactions on Professional Communication, Vol. PC-24, No. 1:17-27 (1981).

[7]Beverly van Orden Roller, "Graph Reading Abilities of Thirteen-Year-Olds," in Paul A. Kolers, Merald E. Wrolstad and Herman Bouma, Processing of Visible Language, 2 (New York: Plenum, 1980), 305-314.

[8]Tankard, op. cit.

[9]Bernard Berelson and Gary A. Steiner, Human Behavior: An Inventory of Scientific Findings (New York: Harcourt, Brace & World, 1964), p. 104.

[10]David Simkin and Reid Hastie, "Towards an Information Processing View of Graph Perception," Proceedings of the Section on Statistical Graphs (Washington, D.C.: American Statistical Association, 1986), 11-20.

[11]Five of the graphs were based on charts in USA Today, and one was based on a chart from the Austin American-Statesman. The topics were sales of different brands of beer in 1986, sales of different kinds of music in 1985, the Dow Jones average over a period of seven years, the average births per day in the United States, the leading causes of death in the 1980s and personal computer sales over a period of seven years.

[12]Doris Graber, Processing the News: How People Tame the Information Tide (White Plains, N.Y.: Longman, 1984).

[13]Simkin and Hastie, op. cit.; William Winn, "Visualization in Learning and Instruction: A Cognitive Approach," Educational Communication and Technology 30 (1):3-25 (1982).